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JC639 U.S. PTO

PATENT APPLICATION TRANSMITTAL LETTER

(Small Entity)

Docket No.
277-P-32-USA

TO THE ASSISTANT COMMISSIONER FOR PATENTS

Transmitted herewith for filing under 35 U.S.C. 111 and 37 C.F.R. 1.53 is the patent application of:

DAVID R. SCOTT

For: METHOD OF INSURING AGAINST SATELLITE LAUNCH FAILURE

Enclosed are:

- ☒ Certificate of Mailing with Express Mail Mailing Label No. EL094153201US
- ☒ 8 sheets of drawings.
- ☐ A certified copy of a _____ application.
- ☒ Declaration ☐ Signed. ☒ Unsigned.
- ☒ Power of Attorney
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- ☐ Preliminary Amendment
- ☒ 1 Verified Statement(s) to Establish Small Entity Status Under 37 C.F.R. 1.9 and 1.27.
- ☐ Other:

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	7	- 20 =	0	x \$9.00	\$0.00
Indep. Claims	4	- 3 =	1	x \$40.00	\$40.00
Multiple Dependent Claims (check if applicable) <input type="checkbox"/>					\$0.00
BASIC FEE					\$355.00
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- ☒ A check in the amount of \$395.00 to cover the filing fee is enclosed.
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Dated: November 15, 2000



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Applicant(s): **DAVID R. SCOTT**

Docket No.

277-P-32-USA

Serial No.

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Examiner

Group Art Unit

Invention: **METHOD OF INSURING AGAINST SATELLITE LAUNCH FAILURE**

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**VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY
STATUS (37 CFR 1.9(f) AND 1.27 (b)) - INDEPENDENT INVENTOR**

Docket No.
277-P-32-USA

Serial No.

Filing Date

Patent No.

Issue Date

Applicant/ **DAVID R. SCOTT**
Patentee:

Invention: **METHOD OF INSURING AGAINST SATELLITE LAUNCH FAILURE**

As a below named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under section 41(a) and (b) of Title 35, United States Code, to the Patent and Trademark Office with regard to the invention entitled above and described in:

- ☒ the specification to be filed herewith.
☐ the application identified above.
☐ the patent identified above.

I have not assigned, granted, conveyed or licensed and am under no obligation under contract or law to assign, grant, convey or license, any rights in the invention to any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

- ☒ No such person, concern or organization exists.
☐ Each such person, concern or organization is listed below.

***NOTE:** Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities (37 CFR 1.27)

FULL NAME

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☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

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I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF INVENTOR David R. Scott

SIGNATURE OF INVENTOR _____ DATE: _____

NAME OF INVENTOR _____

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METHOD OF INSURING AGAINST SATELLITE LAUNCH FAILURE

BACKGROUND OF THE INVENTION

5 The present invention relates to methods of insuring against satellite failure.
More particularly, the present invention relates to methods of obtaining insurance and
protection against the launch of satellites into unintended non-operational Earth orbits.

10 The manufacture of communications, Earth observation, navigation and science
satellites is experiencing a period of extraordinary growth that is expected to continue
into the future. Present estimates indicate that approximately 70 large satellites are
projected to be launched into earth orbit each year during the next ten years for both
commercial and government uses resulting in almost 700 new Earth orbiting satellites.
The satellites continue to increase in size, complexity and cost and with the increased
number of satellites being produced, the satellite industry is estimated to obtain
15 revenues of \$171 billion in the year 2007.

 The launch phase of a satellite deployment into orbit includes two basic steps
performed in sequence. First, the satellite is launched from the Earth's surface through
the atmosphere into space to a transfer orbit. Secondly, the satellite is transferred to a
higher orbit, typically geosynchronous orbit. The first segment is typically conducted

by a launch vehicle such as the Space Shuttle, Titan, Delta, Atlas, Arian, Long March
or Proton rockets. Meanwhile, the second segment is typically performed by a transfer
vehicle which may comprise the upper stage of the rocket or may comprise a perigee
kick motor (PKM) or apogee kick motor (AKM) attached to the satellite. The launch
5 phase is then considered complete when the satellite is separated from the transfer
vehicle.

Unfortunately, a significant percentage of satellites fail due to their failure to
reach their intended orbit or due to their failure to operate correctly once in orbit. In
November 1992, a "90-day satellite salvage study" was conducted jointly by NASA and
10 the International Technology Underwriters, Inc. (INTEC) to identify the commercial
risk allocation due to satellite failure. The study evaluated the historical failure
statistics of 328 large satellites having an on orbit replacement value of \$170 million or
greater which were launched between 1980 and 1992. Though this study was
conducted several years ago, recent research indicates that the applicable percentages
15 have not changed significantly over the past decade. Among the 328 satellites studied,
64 experienced some form of total or significant failure resulting in total loss as
reflected in the table below.

Type Failure (328 launches)

	<u>Number</u>	<u>Percent of Total</u>	
5	Ascent to LEO ("launch failure")	21	6.4
	LEO to higher orbit ("Boost Failure")	13	4.0
	Satellite during Checkout (C/O Failure)	19	5.8
	Satellite during Operations (Ops Fail)	11	3.4
	Successful	264	80.5
	Total	328	

10 This study reflects that of the 328 satellites, 34 (10.4%) of all large
geostationary satellites that have been declared a total loss have been lost during the
"launch phase" with the remaining satellite total losses occurring during on orbit check
out or during subsequent lifetime operations. The risk of total loss of a satellite during
the launch phase can be divided into two categories. The first category includes
15 satellites that have suffered catastrophic failure of the launch vehicle accounting for
6.4% of all total losses. The second category, called "boost failure", includes the total
losses of satellites caused by the failure of the satellite to reach its intended orbit due to
degraded performance of the launch vehicle or transfer vehicle, accounting for 4.0%
of all total losses. Thus, in numerous instances, fully functional satellites are declared
20 a total loss because the satellites have failed to reach their intended orbits. Assuming
that this pattern continues, which it has for almost forty years, and assuming that 700
new Earth orbiting satellites will be launched in the next ten years, approximately 28
satellites will be launched (or 2.8 satellites per year) in the next ten years which are
fully functional but will result as a total loss due to their inability to operate in an
25 incorrect orbit.

If insured, the total sum of the spacecraft loss including launch expenses is paid by the insurance underwriters, typically \$250 million or more for each failure.

However, the primary business loss of a launch failure is usually the long delay in obtaining a new or replacement satellite which can take up to two to three years. This delay in obtaining a replacement satellite can cause the total loss of a planned business due to competition and market changes during the interim.

Attempts have been made to "recover" a few of these fully functional satellites in inoperable orbits. For example, after the Weststar 6 and Palapa B2 satellites were launched to a low Earth orbit instead of geosynchronous orbit due to failure of their solid rocket motors to properly fire, the satellites were retrieved in the Space Shuttle. The satellites were then refurbished on Earth and relaunched into correct orbits where they became fully functional. Meanwhile, Intelsat VI, a very large satellite intended for geosynchronous orbit, was inadvertently launched to a low Earth orbit due to miswiring between the satellite and its attached solid rocket motor. The Space Shuttle performed a recovery mission in which three astronauts conducted a complex extra vehicular activity (EVA) in order to remove the inoperable solid rocket motor and substitute it with a functional solid rocket motor. Thereafter, the solid rocket motor was remotely fired and transported the Intelsat 6 satellite to the correct orbit where the satellite was fully functional. Unfortunately, Shuttle launch and operations including EVA activities are very dangerous and extremely expensive.

Recently, an attempt has been made to overcome these risks to human life and high expenses by the development of a recovery mission wherein a remotely controlled extension spacecraft is made to attach to the satellite located in the unintended orbit. Using the guidance, navigation, control and propulsion systems of these extension spacecraft, the satellite is transported to its intended orbit. A complete description of this recovery mission is described in U.S. Patent No. 6,017,000 which is incorporated herein by reference. The use of an extension spacecraft to move a satellite to its intended orbit is substantially less expensive than manned Space Shuttle missions which typically cost about \$400 - \$500 million, and substantially less than the cost of manufacturing and launching a replacement satellite which typically cost between \$250 million and \$1.2 billion, as in the case of AF Milstar 2 . However, the cost for the manufacture, launch and operation of the extension spacecraft to correct the satellite's orbit still costs \$100 million.

Due to the high expenses and risks involved in attempting to recover a satellite, numerous satellites have been declared a total loss due to their launch to an inoperable orbit even though the satellite is fully functional. For example, since 1993 each of the following ten satellites could have been recovered by the Space Shuttle or by the use of an extension spacecraft.

Recent Recoverable Satellites

	<u>Satellite</u>	<u>Launch Vehicle</u>	<u>Boost Failure</u>	<u>Cost/Loss Claims</u>
	Navy UHF-1	Atlas 1	March 1993	\$187M
	Japan ETS-6	H-2 AKM	April 1994	\$425M
5	Koreasat-1	Delta II	June 1995	\$64M
	ChinaSat-7	Long March 3	June 1996	\$128M
	AsiaSat-3	Proton/DM	December 1997	\$220M
	Japan COMETS	Japanese H-2	January 1998	\$480M
	AF DSP-19	Titan IV/IUS	April 1999	\$682M
10	AF Milstar 2	Titan IV/Centaur	April 1999	\$1,233M
	Orion 3	Delta III/Centaur	May 1999	\$265M

There is thus a significant need for a system that would reduce the risk to satellite owners of their satellite being launched into an incorrect orbit resulting in the total loss of the spacecraft or the high expenses of a recovery mission.

15 One way to reduce the risk of total loss of a satellite is to obtain conventional launch insurance. Typically conventional launch insurance is implemented as follows. First, a satellite owner determines the amount of insurance to be purchased for the satellite launch referred to herein as the "sum insured". The sum insured may include just the cost to manufacture the satellite, but typically also includes the launch costs as

20 well as the cost of insurance for the satellite and launch. Once the sum insured has

been determined, an insurance broker attempts to obtain insurance coverage from a number of underwriters in the market, while at the same time attempting to obtain the lowest premium rate for his client. The underwriter establishes a premium rate for the satellite launch as a measure of the risk of launch. The premium rate may be a total percentage value of the sum insured incorporating the risks for various aspects of launch such as the risk of launch vehicle failure, boost failure, spacecraft failure at checkout and spacecraft failure during operations. In the alternative, the rate can be divided into separate categories. For example, the risk of launch can be divided into specific risks of launch failure and boost failure. The cost to the spacecraft owner of the insurance is thus a product of the sum insured times the total premium rate. This premium payment is paid by the satellite owner to the broker who typically separates the payment into two segments representing the payment insuring against launch vehicle failure and boost failure. The premium payment is then proportionally distributed to the several underwriters according to the amount of risk assumed by each. In the event of a launch failure, the underwriters are obligated to pay the total loss (sum insured) to the owner who may use these proceeds to manufacture and launch a replacement satellite. Similarly, in the event of a boost failure, the underwriters are also obligated to pay the total loss (sum insured) to the owner who may use these proceeds to manufacture and launch a replacement satellite. For purposes herein, the insurance broker and underwriters will be collectively referred to herein as a guarantor.

Unfortunately, conventional launch insurance does not assist in rescuing a satellite which is otherwise fully functional but placed in an unintended orbit during a boost failure.

SUMMARY OF THE INVENTION

5 The present invention addresses the aforementioned disadvantages by providing an improved method of insuring against satellite failure wherein the insurance policy provides for the funding and initiation of a recovery mission to recover an orbiting satellite if it has been determined that the satellite is otherwise fully functional but non-operational due to its accidental placement in a non-operational orbit. More
10 particularly, after contracting for the manufacture of a satellite, the satellite owner includes in a conventional insurance policy from a guarantor an additional provision to provide for a recovery mission in the event that the satellite is ultimately launched into an unintended non-operational orbit but the satellite is otherwise fully functional.

15 The recovery mission provides for moving the satellite by external physical manipulation of the satellite from its resulting launch orbit to an intended operational orbit. The satellite may be moved by implementing various types of recovery missions. For example, the satellite may be recovered in similar manner to the recovery of the Weststar 6 and Palapa B2 satellites by recovering the satellite in the Space Shuttle and thereafter relaunching the satellite to its intended orbit by using an additional launch

vehicle. Alternatively, the recovery mission may entail attachment of a booster vehicle to the satellite and thereafter igniting the booster vehicle to transfer the satellite from its unintended orbit to an intended orbit in similar manner to the reboost of the Intelsat VI satellite.

5 Preferably, the recovery mission includes launching an unmanned extension spacecraft to mechanically connect to the target satellite and thereafter move the satellite-spacecraft combination to its desired orbit. To perform the recovery mission, the extension spacecraft includes guidance, navigation and control systems, an onboard propellant supply and a docking system for mechanically connecting the extension spacecraft to the target satellite to form a docked satellite-spacecraft combination. The 10 guidance navigation and control systems of the extension spacecraft provide the means for controlling the position of the docked satellite-spacecraft combination. Meanwhile, the extension spacecraft is provided with sufficient propellant supply to provide for rendezvous and docking of the extension spacecraft with the target satellite and for 15 subsequently transferring the satellite-spacecraft to its intended orbit.

 In a preferred embodiment, the launch insurance of the present invention also includes insuring against failure of the recovery mission. To this end, the satellite owner or original guarantor obtains an insurance policy from providing protection against failure of the recovery mission to properly move the satellite from an 20 unintended non-operational orbit to an intended orbit. The insurance policy includes

the coverage for the additional risk of rendezvous, docking and transfer of the satellite, and preferably provides for monetary compensation to cover the original sum insured for the total loss of the satellite including compensation for payment of the satellite and its launch. In the alternative, the recovery mission failure insurance policy may also
5 provide for funding and initiating an additional recovery mission where feasible.

Thus, the method of insuring against satellite failure of the present invention includes "recovery reservations" to safe guard against a launch boost failure. The "reservation" entitles the satellite owner to a fully insured Recovery Mission at no additional cost and no additional insurance premium. In operation, after purchasing a
10 satellite, the satellite owner then consults with satellite guarantors including insurance brokers and underwriters to obtain this safeguard against accidental launch of a functioning satellite into an unintended non-operational orbit. The insurance policy may also include provisions for compensation to the satellite owner to cover other contingencies such as catastrophic loss of the spacecraft during launch, check out or
15 operations.

Once the spacecraft has been manufactured and the insurance policy has been obtained, the satellite is launched onboard any of the launch vehicles available such as the Space Shuttle, Arian, Atlas, Delta, Titan, Long March, Sea Launch or Proton launch vehicles. If the satellite fails to reach its intended orbit but is otherwise
20 functional, the guarantor funds and initiates the commencement of a recovery mission

to move the satellite from the unintended orbit to an intended orbit. Preferably, the recovery mission includes the launch of an extension spacecraft within three months of the launch failure so that the satellite may be moved into its intended orbit as soon as possible to thereby minimize any affects on the non-operation of the satellite upon the satellite owner's business.

The cost of the recovery mission is entirely borne by the guarantor and thus the satellite owner benefits from the recovery mission by not having to wait two or more years to obtain a replacement satellite. Meanwhile, the recovery mission benefits the guarantor, even though the costs of the recovery mission must be borne by the guarantor, as the cost of the recovery mission is significantly lower than payment of the sum insured which would include the expense of a new replacement satellite and typically the expense of the additional satellite launch, as well as the expense of insurance for the replacement satellite and its launch.

Preferably, the original insurance policy also includes a provision protecting the satellite owner against failure of the recovery mission.

Other features and advantages of the present invention will be appreciated by those skilled in the art upon reading the detailed description which follows with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a flow chart illustrating the method of insuring against satellite launch failure of the present invention;

Fig. 2 is a bar chart illustrating the cost savings resulting from purchasing
5 launch insurance including provision for a recovery mission of the present invention;

Fig. 3 is a perspective view of an extension spacecraft, configured to provide a recovery mission;

Fig. 4 is a partially cut-away perspective view of the service module of the extension spacecraft of Fig. 3;

10 Fig. 5 is a perspective view of the command module of the extension spacecraft of Fig. 3;

Fig. 6 illustrates the docking maneuvers and mechanical interconnection of the extension spacecraft with a target satellite; and

Figs. 7 - 9 illustrate a typical mission scenario performed by an extension spacecraft to transfer a satellite from an unintended inoperable orbit to an intended operational orbit.

DETAILED DESCRIPTION OF THE INVENTION

5 While the present invention is susceptible of embodiment in various forms, there is shown in the drawings and will hereinafter be described the presently preferred embodiments of the invention with the understanding that the present disclosure is to be considered as an exemplification of the invention and it is not intended to limit the invention to the specific embodiments illustrated.

10 With reference to Fig. 1, the present invention is directed to a method of obtaining launch insurance by a satellite owner to protect the satellite owner against accidental boost failures during satellite launch which place functional satellites in inoperable orbits. After purchasing a satellite 101 the owner typically obtains satellite insurance to cover any failure of the satellite either during launch or after orbit

15 insertion. The satellite owner determines the amount of insurance to be purchased (the sum insured) which would typically cover the costs of satellite manufacture, satellite launch, launch insurance and other expenses to deploy the satellite. For purposes of the present invention, the satellite launch component is broken into two components. Insurance is obtained to cover launch risks including catastrophic failure of the launch

vehicle, and failure of the satellite to reach its intended orbit due to a malfunction of the launch vehicle or booster vehicle. The failure of the satellite to reach its intended orbit is defined herein as "boost failure". The launch insurance also includes a recovery mission provision 103 to provide insurance coverage for the funding and initiation of a recovery mission in the event that the insured satellite is launched into an unintended orbit but otherwise fully functional. Thus, the satellite owner includes a recovery mission "reservation" within the launch insurance agreement entitling the satellite owner to a recovery mission at no cost in the event the satellite experiences a boost failure during launch and is deemed recoverable. Further, the Recovery Mission will be initiated much sooner than the time required to build and launch a new replacement satellite.

Still with reference to Fig. 1, after the satellite is launched 105, three scenarios are possible. In the majority of instances, the launch and orbital insertion of the satellite is completed entirely successfully 107. In this instance, the insurance payment has been made to the policy guarantor and the satellite owner takes control and operation of the orbital satellite. No further interaction between the satellite owner and guarantor is necessary. An alternative scenario, which occurs in approximately 6% of all satellite launches, results in catastrophic failure 111 of the satellite such as by an explosion of the launch vehicle or booster vehicle during launch or orbital transfer. In this instance, the guarantor must pay the satellite owner the sum insured in the insurance policy for total loss of the satellite 115.

In approximately 4% of all launches a booster failure 109 occurs resulting in a functional satellite being accidentally launched into an inoperable orbit. Where an insurance policy of the present invention has been obtained by the satellite owner, the guarantor pays for the initiation of a recovery mission 113 in an effort to transfer the satellite into an intended orbit. Where the recovery mission is successful, the satellite commences its intended operation such as providing communications, Earth observation or other scientific purposes 123.

In the unlikely event that the recovery mission fails 117 to properly transfer the satellite from its inoperable orbit to a correct and intended orbit, preferably the launch insurance policy provides for the satellite owner being completely compensated for the total loss of the satellite. In still an additional preferred embodiment of the invention, the launch insurance includes a recovery mission "reservation" provision which provides for the recovery mission being launched within three months after boost failure to minimize the satellite owner's risk due to the delay in the manufacture and launch of a recovery mission or launch of a replacement satellite.

The economics of the recovery mission insurance policy concept are based on the substantial difference between the total cost of a satellite recovered and the much higher total cost for the manufacture and launch of a replacement satellite. This difference in total cost can be utilized to benefit all parties involved including the satellite owner, the insurance underwriters and the insurance broker. The recovery

mission "reservation" provision maximizes the probability of successfully delivering a satellite to its intended orbit, minimizes the satellite owner's market risk by initiating a recovery mission to expedite satellite revenue operations at the earliest opportunity, and minimizes the financial loss in the event of a boost failure.

5 **Example 1**

In a preferred practice of the present invention, launch insurance including a policy for providing a recovery mission is provided to the satellite owner at a cost less than the premium for obtaining conventional insurance.

On May 5, 1999, the Orion 3 communications satellite was launched into an
10 unplanned orbit by the failure of the Centaur upper stage on the Boeing Delta III launch
vehicle. According to public reports, the satellite was launched into an orbit of 85 X
744 nautical miles, far short of its specified launch insertion orbit of 100 X 13,886
nautical miles. On May 7, 1999, Orion 3 was transferred to an orbit of 228 X 711
nautical miles to prolong its life. The satellite appears to be fully functional but does
15 not have sufficient onboard propellant to transfer it to its planned geostationary orbit of
22,300 nautical miles. The satellite and launch were insured for \$265 million. It has
been estimated that it would cost approximately \$186.7 million to initiate a recovery
mission employing an extension spacecraft to recover the Orion 3 satellite. This
recovery mission costs includes full insurance at a cost of \$58.3 million (at a 22%

premium rate times sum insurance \$265 million) to provide full compensation to the Orion 3 owner in the event the recovery mission were unsuccessful.

With reference to Fig. 2, conventional launch insurance may be divided into segments including separate premium rates for launch vehicle failure and boost failure.

5 Thus, the launch of the Orion 3 at a premium rate of 8% would typically be divided into a launch vehicle failure premium rate of 4.5% and a boost failure premium rate at 3.5%. If conventional launch insurance were obtained, these rates would be multiplied by the sum insured of \$265 million to establish segmented premiums of \$11.8 million and \$9.4 million, respectively, to provide a total premium of \$21.2 million paid by the
10 satellite owner.

However, if the satellite owner of Orion 3 had obtained launch insurance including provisions for a recovery mission, the insurance premium to cover boost failure would be reduced as the guarantor would not be required to pay the sum insured of \$265 million, but instead would be required to pay for a recovery mission of \$186.7
15 million in the event of a boost failure. Thus, the insurance premium to cover boost failure would amount to \$6.5 million, significantly less than the \$9.4 million required of conventional insurance. Thus, the insurance policy of the present invention including provision for a recovery mission would have lowered the insurance premium to the owner of Orion 3 by almost \$3 million to \$18.3 million.

In a preferred practice of the invention, the \$2.8 million in insurance savings would have been paid to the company providing the recovery mission as payment to guarantee that a recovery mission would be conducted within a specified period of months of the satellite launch. For example, if the satellite owner of Orion 3 had obtained such a policy, the satellite owner would have paid \$2.8 million to a company providing recovery missions to ensure that a recovery mission could be launched within, for example, three months of the satellite launch. The cost to the satellite owner of Orion 3 to obtain launch insurance including a recovery mission policy providing for a recovery mission to be launched within three months of boost failure would thus cost the exact same amount (\$21.2 million) as conventional launch insurance.

Orion 3 - Insurance Summary

		<u>Rate</u> (%)	<u>Amount</u> (\$M)
15	<u>1. Original Launch - Conventional</u>		
	Sum Insured		265.0
	Launch Phase Premium Rate (est) 8.0		
	Launch Phase Premiums (estimate)		
	Launch Vehicle Failure	4.5	11.8
20	Boost Failure	3.5	9.4
	Total Premium		21.2
	<u>2. Recovery Cost</u>		
	Recovery Mission (w/Profit %)		128.5
	Insurance for RM		
25	Sum insured		265.0
	Premium Rate/Cost	22.0	58.3
	Total Recovery Cost		186.7

	<u>3.</u>	<u>Original Launch with Reservation</u>		
		Sum Insured		
		Launch Vehicle Failure		265.0
		Boost Failure		186.7
5		Launch Phase Premium Rate	8.0	
		Launch Phase Premiums		
		Launch Vehicle Failure	4.5	11.8
		Boost Failure	3.5	6.6
		Total Premium w/Res		18.4
10	<u>4.</u>	<u>Reservation Premium Residual (Savings)</u>		
		Conventional Premium		21.2
		Premium with Reservation		18.4
		Standby Mission Premium		2.8

CONFIDENTIAL

Example 2

The following example is presented to illustrate a preferred practice of the invention including variables involved for a higher value satellite launched on a lower risk launch vehicle. This "satellite X" is ensured for \$430 million and is launched on the Ariane 4 launch vehicle.

Satellite X - Insurance Summary

		Launch Vehicle:	Ariane 4		
			<u>Rate</u>	<u>Amount</u>	
			(%)	(\$M)	
10	<u>1.</u>	<u>Original Launch - Conventional</u>			
		Sum Insured		430.0	
		Launch Phase Premium Rate (est) 4.5			
		Launch Phase Premiums (estimate)			
		Launch Vehicle Failure	2.5	10.8	
15		Boost Failure	2.0	8.6	
		Total Premium		19.4	
	<u>2.</u>	<u>Recovery Cost</u>			
		Recovery Mission (w/Profit %)		154.0	
		Insurance for RM			
20		Sum Insured		430.0	
		Premium Rate/Cost	22.0	94.6	
		Total Recovery Cost			248.6
	<u>3.</u>	<u>Original Launch with Reservation</u>			
		Sum Insured			
25		Launch Vehicle Failure		430.0	
		Boost Failure		248.6	
		Launch Phase Premium Rate	4.5		
		Launch Phase Premiums			

Launch Vehicle Failure	2.5	10.8
Boost Failure	2.0	4.9
Total Premium w/Res		15.7

5	4. <u>Reservation Premium Residual (Savings)</u>	
	Conventional Premium	19.4
	Premium with Reservation	15.7
	Standby Mission Premium	3.6

From the foregoing table, one can see that a savings of \$3.6 million can be obtained by purchasing launch insurance including a recovery mission policy instead of purchasing conventional launch insurance. The \$3.6 million dollars will be passed on to the satellite owner, insurance broker and insurance underwriters as either savings or additional profit. The conventional launch insurance would cost approximately \$19.4 million including \$10.8 million at a 2.5% premium rate and \$8.6 million for a boost failure premium at 2.0% premium rate. Meanwhile, assuming a recovery mission cost of \$248.6 million including an insurance premium of \$94.6 million, the boost failure premium component of launch insurance including a recovery mission policy would be reduced by \$3.6 million as the premium rate of 2.0% is multiplied by the recovery mission cost instead of the sum insured for the satellite.

The \$3.6 million is preferably paid by the satellite owner as the part of the insurance premium to the insurance broker to provide the recovery mission as a "reservation" to conduct a recovery mission within three months of satellite launch if there is a boost failure. Again, the satellite owner is provided with a launch insurance

policy including provision for a recovery mission within three months of a boost failure at the same cost of obtaining conventional launch insurance.

Example 3

In a non-preferred embodiment of the invention, the insurance policy for a recovery mission is offered to a satellite owner at a price in addition to the cost of a conventional launch insurance policy. As is explained in greater detail above, the premium for launch insurance including the recovery mission provision would more likely be less costly than conventional launch insurance. However, for purposes of simplicity and explanation, this example will describe an insurance policy of the present invention in which the recovery mission policy is paid for in addition to conventional launch insurance.

In March 1994 the U.S. Navy launched a military communications satellite UHF-1 on an Atlas I which suffered a boost failure. The estimated value for the satellite was \$142 million with an additional \$45.7 million for launch, for a total of \$187.7 million. A 12% insurance rate was charged to the U.S. Navy resulting in a \$22.5 million insurance premium.

Recovery mission insurance was not obtained by the U.S. Navy. However, the U.S. Navy most likely could have obtained such a policy at a rate of approximately 4%

of the total value of the UHF-1 mission, or approximately \$75 million. In a preferred practice of the invention, after it had been determined by the guarantor that the UHF-1 satellite was recoverable, the guarantor would have refunded the cost of all mission insurance premiums to the U.S. Navy as an incentive to the Navy to purchase the recovery mission policy thereby providing a refund to the U.S. Navy of \$22.5 million. The U.S. Navy would have transferred all right, title and interest in the conventional insurance policy to the guarantor in order to exercise the recovery mission policy in which the guarantor would have paid for a fully insured recovery mission. In this example, the guarantor is essentially "buying the owner out" of its claims under the conventional insurance policy by refunding the insurance premiums and committing to the recovery mission.

On completion of a successful recovery mission, in which the satellite is delivered to its intended orbit, control of the satellite is delivered to the owner and the guarantor does not pay any additional claims. If the recovery mission is unsuccessful, the guarantor makes an additional payment to the satellite owner equal to the total value of the claims (\$187.7 million) less the cost of the original recovery mission insurance premium (\$22.5 million) which has already been refunded for a total claim payment of \$165.2 million.

Meanwhile, where the guarantor has funded a recovery mission utilizing an extension spacecraft to transfer the satellite to its intended orbit, the entire recovery

mission including insurance would have been completed for approximately \$105.6 million (1994) dollars. The expenses for such a mission are set forth as follows.

	<u>Element</u>	<u>Cost (\$M)</u>
	Mission Cost	
5	Launch (Atlas I, UHF-1 relaunch guaranty)	45.7
	Spacecraft (Option B, Feasibility Analysis)	18.6
	Subtotal	64.3
	Insurance	
	Launch (@22% of Satellite Insured Sum)	41.3
10	Total Cost	105.6

Neither the U.S. Navy nor the guarantor would have been exposed to any additional financial loss due to the initiation of the recovery mission. The U.S. Navy would have obtained the opportunity to take possession of a fully functional satellite in an intended orbit long before an additional satellite could be launched. Moreover, where the mission was successful, the original guarantor would have spent significantly less money on funding a recovery mission than having to pay for total compensation of the UHF-1 satellite and launch. Conversely, even if the recovery mission was unsuccessful, the U.S. Navy would have been compensated for the full amount of the satellite and launch and the original guarantor would have been protected against failure of the recovery mission by obtaining recovery mission failure insurance which would have provided compensation sufficient to cover an insurance payment to the satellite owner of the sum insured.

Recovery Missions

The recovery missions may take various formats. For example, the satellites may be recovered by being returned to Earth such as within the Space Shuttle for refurbishment and relaunch into an intended orbit. In the alternative, the recovery mission may include the manual attachment of a transfer vehicle to the satellite, such as the attachment of a solid rocket motor, and the remote firing of the motor to transport the satellite to an intended orbit. However, for purposes of practicing the present invention it is preferred that the recovery mission include the launch and operation of an unmanned extension spacecraft.

Turning now to the drawings, Figs. 3 - 5 illustrate an extension spacecraft constructed in accordance with and used in accordance with the principles of the present invention. The spacecraft 10 comprises a command module 11 and a service module 12. The extension satellite embodies exoatmospheric construction and is adapted to be carried into space, e.g., to a rendezvous phasing orbit or low Earth orbit in the enclosed cargo bay or within the enclosing shroud of an earth launch vehicle (ELV) such as, for example, the Delta or the Space Shuttle, depending on mission requirements, availability, cost, etc. For example, in one embodiment of the invention, the baseline earth launch vehicle is the Delta 7920, which has a low earth orbit payload insertion capability of approximately 5,000 kilograms and a geosynchronous transfer orbit capability of approximately 1,300 kilograms.

The service module 12 operates as a "space bus" for the command module 11, providing among other functions, propulsion, power and communications support, thus minimizing the requirements for corresponding subsystems in the command module 11. The operations phase design lifetime of the command module 11 for in-space servicing can therefore be relatively short, based on specific programmed tasks at the target vehicle during a fixed period of activity. If necessary, the command module 11 will separate from the service module 12 and operate independently. Also, for certain missions, a satellite transfer vehicle (STV), such as that disclosed in my issued U.S. Patent No. 5,242,135, can be employed to transfer the extension spacecraft 10 from the launch insertion orbit to a rendezvous phasing orbit (RPO).

As will be apparent to those skilled in the art, all of the functions of the command module 11 could be incorporated into the service module 12, although the separate command and service modules herein described provide for maximum mission flexibility and are, accordingly, a presently preferred embodiment of the invention.

Referring more particularly to Fig. 4, the primary purpose of the service module 12 is to augment the propulsion capabilities of the command module 11. For example, if the command module 11 is configured as a variant of the SDIO Lightweight Exoatmospheric Projectile (LEAP) Vehicle, the service module 12 can be based on the design of the existing "Small Altimeter" (SALT) satellite manufactured for the United States Navy by Intraspace, Inc., North Salt Lake City, Utah. The service module 12

includes a command module adapter ring 21, GPS antenna 22, S-Band OMNI antenna 23, orbit insertion motors 24, propellant tanks 25, batteries, 26. Mounted on the mid-deck 27 is a reaction control system 28 and on-board processor 29. These components are enclosed by a monocoque structure 30, on which are mounted solar power cell arrays 31.

The service module 12 is sized to perform all rendezvous and proximity maneuvers, as well as specific transfer maneuvers required for the extension spacecraft-target satellite docked combination. For certain target spacecraft locations, the energy requirements to position the extension spacecraft for rendezvous may be greater than that available from the service module 12, for example, an inclination change for the target satellite. In such cases, the STV would be added to the extension spacecraft to augment the propulsion capabilities of the service module 12.

For major maneuvers, the service module 12 is equipped with a storable biopropellant system consisting of a "quad" array of four uprated Marquardt R-4-D 490 Newton (100 lb.) thrust axial engines. This configuration provides adequate thrust-to-weight ratio to minimize the effects of non-impulsive maneuvers, as well as redundancy for engine-out capability to complete the mission. Marquardt R-4-D engines are selected for their very high reliability, high Isp (322 seconds), maturity (over 800 produced) and availability.

To prevent contamination of the target satellite when the extension spacecraft is stationkeeping, the extension spacecraft attitude control system is a nitrogen cold gas system consisting of 16 x 5 lb. thrusters mounted in quads on the circumference of the service module 12. This configuration enables both three-axis rotation and three-axis translation for example, for stationkeeping and docking.

Referring more specifically to Fig. 3, the command module 11 includes several major subsystems, including guidance, navigation and control (GNC) system used for all extension spacecraft operations, a main propulsion system with "divert" thrusters of approximately 100 lbs. (490 N) thrust each, an attitude control system, and data and communication subsystems. The command module payload consists of a "seeker" subsystem with sensors for target location, tracking and inspection, and a docking system with various servicing devices such as a docking apparatus or robotic arms with clamps or grippers.

The basic configuration of the command module 11 is defined as a completely independent vehicle to enhance mission planning flexibility, minimize interface requirements, maximize the use of existing or developmental small spacecraft, and enable independent testing and verification of certain proximity operations and hardware in ground facilities prior to launch. The command module 11 may remain attached to the service module 12 (as for the UHF-1 recovery mission, described below), or it may be detached to operate autonomously. The service module 12 could,

therefore, carry two or more command modules 11. In such configuration, the service module 12 acts as the primary spacecraft and the command module or modules can be detached for use as observation spacecraft. In either case, prior to separation of the command module(s) 11, certain rendezvous braking maneuvers would be performed by the divert thrusters of the combined command module-service module.

The baseline design command module 11 consists of a variant of the SDIO LEAP with minor modifications. The Rocketdyne AHIT Vehicle is selected as the baseline command module 11. This vehicle has completed several full-up hover tests in the SDIO National Hover Test Facility. In current configuration it weighs 10.2 kilograms, including 1.7 kilograms of propellant. It produces a delta velocity increment of 357 m/sec.

In this configuration, the command module includes cold gas attitude control system thrusters 32 and two divert thrusters 33 which have significantly higher thrust (490 N, 100 lb.) than the service module engines (5 lb.). These divert thrusters 33 are aligned along the line of sight from the service module 12 toward the target satellite. These divert thrusters 33 would not be used in close proximity to the target satellite to preclude contamination of the satellite. The remaining two divert thrusters of the AHIT vehicle are removed.

This forward alignment of the divert thrusters enables the seeker assembly to be continuously oriented toward the target satellite, thus precluding the necessity of rotating the extension spacecraft 180 degrees opposite to the target line of site to perform braking maneuvers. Although the engines 24 of the service module 12 could
5 be used to perform braking, the low thrust level of these engines (20 lbs. total) would result in much longer burn times and very narrow margins in ignition time, burn durations, orbital position, and relative velocity.

Figs. 7 - 9 illustrate a typical recovery mission scenario. Illustratively, this scenario envisions the recovery of the Navy UHF-1 satellite which was launched into a
10 non-operational orbit on March 29, 1993, by a degraded launch vehicle. Subsequently, the Navy stated that the UHF-1 satellite is a total loss. The UHF-1 satellite 41 is in essentially a geosynchronous transfer orbit 51 with a perigee at 118 nm, apogee at 19,365 nm and an inclination at 27 degrees. The recovery flight profile depicted in Figs. 7 - 9 is designed to transfer the satellite 41 into geostationary orbit (GEO) 52 by
15 circularizing the orbit and reducing its inclination to approximately zero degrees.

To accomplish the recovery mission, the extension spacecraft 10 is launched from the Earth by an Earth launch vehicle 53, into a Rendezvous Phasing Orbit (RPO) 54 with a perigee of 180 nm, an apogee of approximately 19,345 nm and an inclination of 27 degrees. After insertion of the extension spacecraft 10 into RPO, a four-impulse
20 sequence is initiated which consists of coelliptic sequence initiation (CSI), constant delta

height (CDH), terminal phase initiation (TPI) and braking. CSI establishes a deextentioned ratio of relative height to phase angle between the extension spacecraft 10 and the target satellite 41. CSI also establishes, based on subsequent maneuvers, the standard lighting conditions as well as transfer time for the final approach to the target 41. CDH establishes a constant differential altitude between the extension spacecraft 10 and the target satellite. TPI establishes an extension spacecraft trajectory that will intercept the target satellite 41 at a specific time and position on the orbit 52 of the target satellite. A nominal transfer interval of 130 degrees is used to optimize propellant usage, provide adequate control authority during the final approach, insure the apparent inertial motion of the target satellite 41 (relative to the star field) as near zero during the latter part of the intercept, and insure that the transfer is along the line of sight. Braking is performed as a series of distinct maneuvers performed at specific range/rate "gates", each of which occurs at a range from the target where the actual range/rate is reduced to a preplanned value. The maneuvers at these gates gradually reduce the relative velocity between the vehicles to zero. After docking of the extension spacecraft 10 with the target satellite 41, the docked combination 57 then perform a series of maneuvers to cause the perigee of the docked combination 58 through intermediate orbits (indicated by the dash lines on Fig. 9) to raise the perigee to 19,365 nm and reduce the inclination to near zero, placing the docked combination in final operational orbit (GEO) 52.

The use of an extension spacecraft to perform a recovery mission provides a relatively inexpensive and reliable means of transferring a satellite from an unintended orbit to an operable intended orbit. By providing the guarantee of a recovery mission including the use of an extension spacecraft within launch insurance reduces the business risk to the satellite owner and maximizes the probability of successfully delivering the satellite to its intended orbit. Launch insurance including provision for a recovery mission also reduces the risk to the guarantor of having to pay total compensation of the sum insured in the event of a launch failure.

Having described my invention in such terms as to enable those skilled in the art to understand and practice it, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

I claim:

1. A method of insuring against satellite failure including recovery reservations comprising the steps of:

acquiring a satellite for orbiting the earth; and

obtaining a launch insurance policy including a recovery mission

5 provision from a guarantor against launch of the satellite into an unintended orbit, the insurance policy including provision for the guarantor initiating a recovery mission to recover the satellite by moving the satellite to an intended orbit if the satellite is launched into an unintended orbit.

2. The method of insuring against satellite failure of Claim 1 wherein:

10 the provision for the guarantor initiating a recovery mission includes providing for moving an unmanned extension spacecraft within proximity of the orbiting satellite, mechanically connecting the extension spacecraft to the orbiting satellite to form a docked satellite-spacecraft combination, moving the satellite-spacecraft combination using the control systems of the extension
15 spacecraft.

3. The method of insuring against satellite failure of Claim 1 further comprising the steps of:

launching the orbiting satellite into an unintended orbit; and

initiating a recovery mission to move the satellite from the unintended

5 orbit to an intended orbit.

4. The method of insuring against satellite failure of Claim 3 further comprising the steps of:

moving an unmanned extension spacecraft within proximity of the orbiting satellite;

10 mechanically connecting the extension spacecraft to the orbiting satellite to form a docked satellite-spacecraft combination; and

moving the satellite-spacecraft combination using the control systems of the extension spacecraft.

5. A method of insuring against satellite failure including recovery reservations comprising the steps of:

acquiring a satellite for orbiting the earth; and

5 obtaining a recovery insurance policy from a guarantor against launch of the satellite into an unintended orbit, the insurance policy including provision for the guarantor initiating a recovery mission to recover the satellite by moving the satellite to an intended orbit if the satellite is launched into an unintended orbit; and

10 obtaining a recovery mission failure insurance policy from a guarantor to provide protection against failure of the recovery mission to move the satellite from an unintended orbit to an intended orbit if a recovery mission is initiated.

6. A method of insuring against satellite failure including recovery reservations comprising the steps of:

launching a satellite into an unintended orbit;

initiating a recovery mission in an attempt to recover the satellite by

5 moving the satellite to an intended orbit; and

obtaining a recovery mission failure insurance policy from a guarantor against failure of the recovery mission to move the satellite from an unintended orbit to an intended orbit to provide monetary compensation for the loss of the satellite.

7. A method of insuring against satellite failure including recovery reservations comprising the steps of:

acquiring a satellite for orbiting the earth; and

5 obtaining a recovery insurance policy from a guarantor against launch of the satellite into an unintended orbit, the insurance policy including provision for the guarantor initiating a recovery mission to recover the satellite by moving the satellite to an intended orbit if the satellite is launched into an unintended orbit;

10 launching a satellite into an unintended orbit;

initiating a recovery mission in an attempt to recover the satellite by moving the satellite to an intended orbit resulting in an unsuccessful attempt to recover the satellite;

15 obtaining a recovery mission failure insurance policy from a guarantor against failure of the recovery mission to move the satellite from an unintended orbit to an intended orbit to provide monetary compensation for the loss of the satellite; and

providing monetary compensation for the loss of the satellite by the guarantor to the policy holder of the recovery mission failure insurance policy.

ABSTRACT

A method of insuring against launch failure is provided to reduce the business risk to the satellite owner and insurance underwriters against satellite launch failure. The launch insurance includes provision for guaranteeing a rapid response recovery mission, preferably at no cost, in the event that a satellite suffers a boost failure during launch resulting in a fully-functional satellite being launched to an unintended inoperable orbit. Preferably, the launch insurance also provides for additional insurance against failure of the recovery mission to provide compensation to the satellite owner in the event that the recovery mission is also unsuccessful.

TRANSMITTAL OF FORMAL DRAWINGSDocket No.
277-P-32-USAIn Re Application Of: **DAVID R. SCOTT**

Serial No.

Filing Date

Batch No.

Examiner

Art Unit

Invention: **METHOD OF INSURING AGAINST SATELLITE LAUNCH FAILURE**Jd658 U.S. PTO
09/713965
11/15/00

Address to:

Assistant Commissioner for Patents
Washington, D.C. 20231

Transmitted herewith are:

8 sheets of formal drawing(s) for this application.

Each sheet of drawing indicates the identifying indicia suggested in 37 CFR Section 1.84(c)
on the reverse side of the drawing.

Signature

David G. Duckworth, Reg. 39,516
DRUMMOND & DUCKWORTH
4590 MacArthur Blvd., Suite 500
Newport Beach, CA 92660Dated: 11/15/00I certify that this document and attached formal drawings
are being deposited on November 15 2000 with the
U.S. Postal Service as first class mail under 37 C.F.R. 1.8
and addressed to the Assistant Commissioner for Patents,
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Signature of Person Mailing Correspondence

Typed or Printed Name of Person Mailing Correspondence

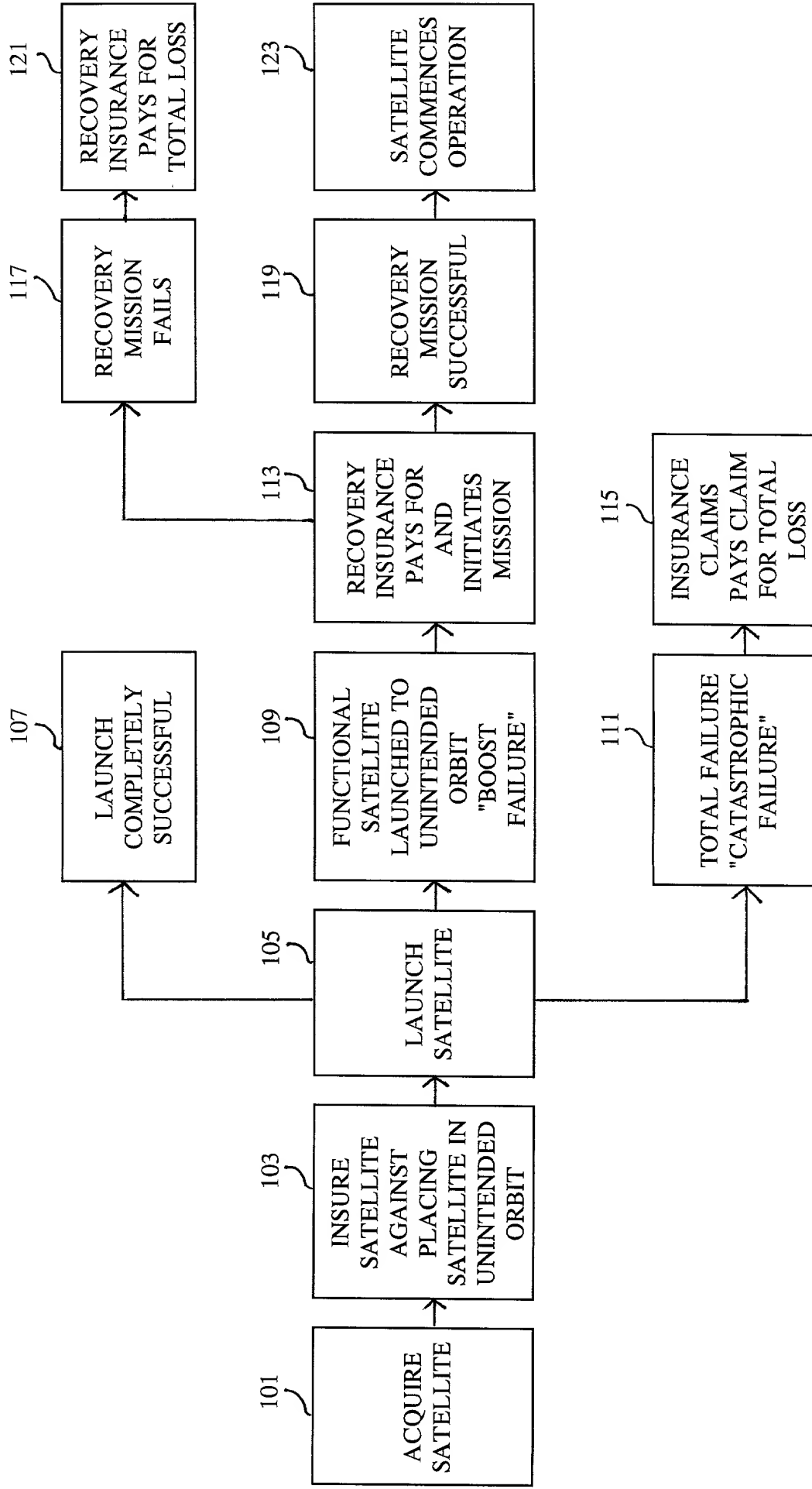


FIG. 1

Figure 1 consists of 12 subplots, labeled (a) through (l), each showing a histogram of the number of non-zero elements in the vector x for a specific value of n . The subplots are arranged vertically. The x-axis for all plots is 'Number of non-zero elements in x ' with major ticks at 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12. The y-axis is 'Frequency' with major ticks at 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. The histograms show a unimodal distribution that shifts to the right as n increases from 1 to 12. For $n=1$ (a), the distribution is centered at 1. For $n=12$ (l), the distribution is centered at 12.

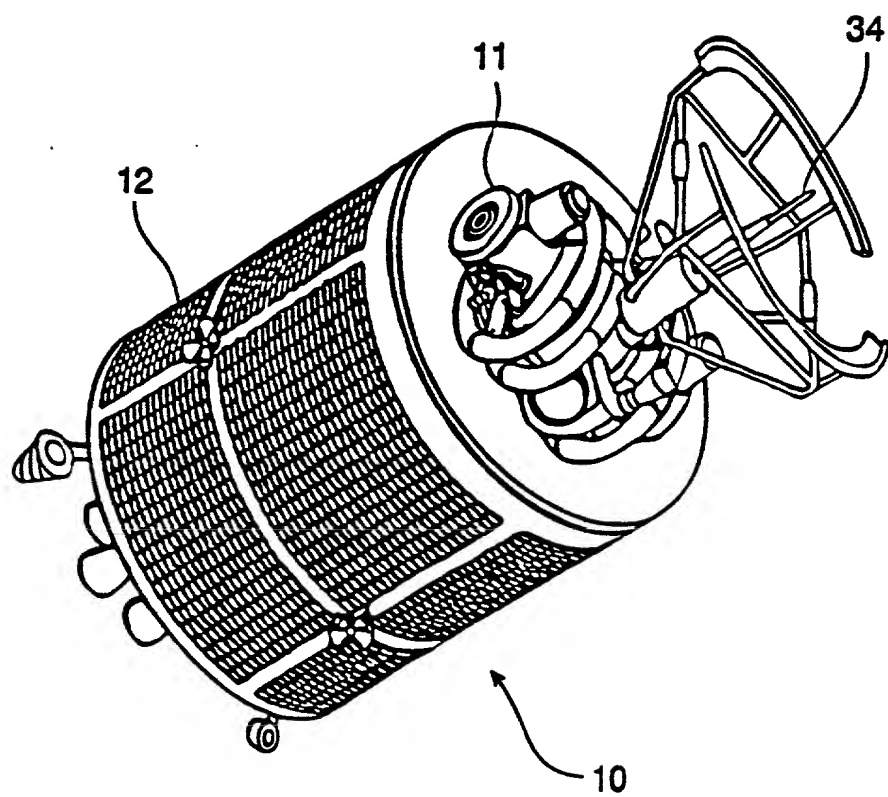


FIG. 3

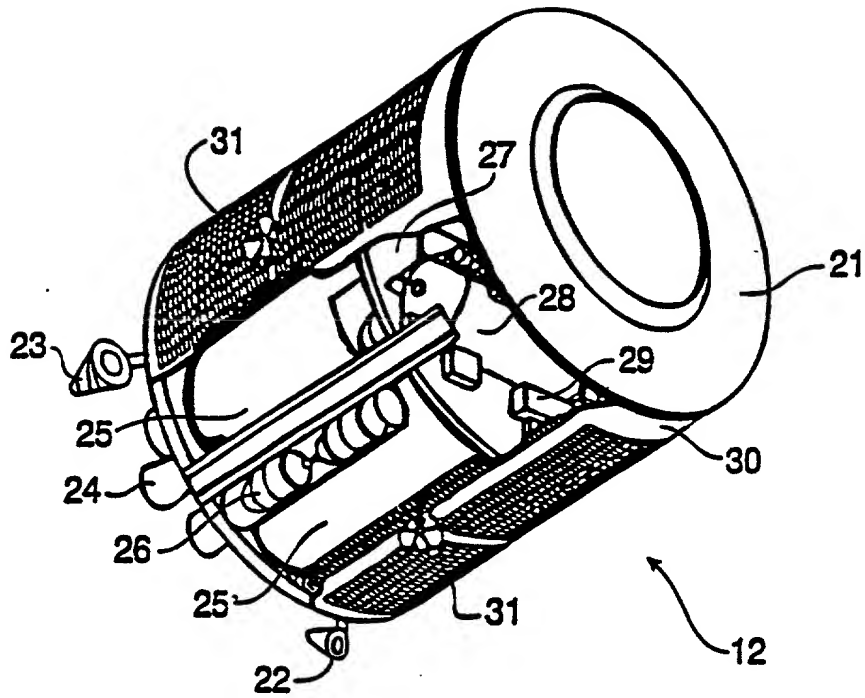


FIG. 4

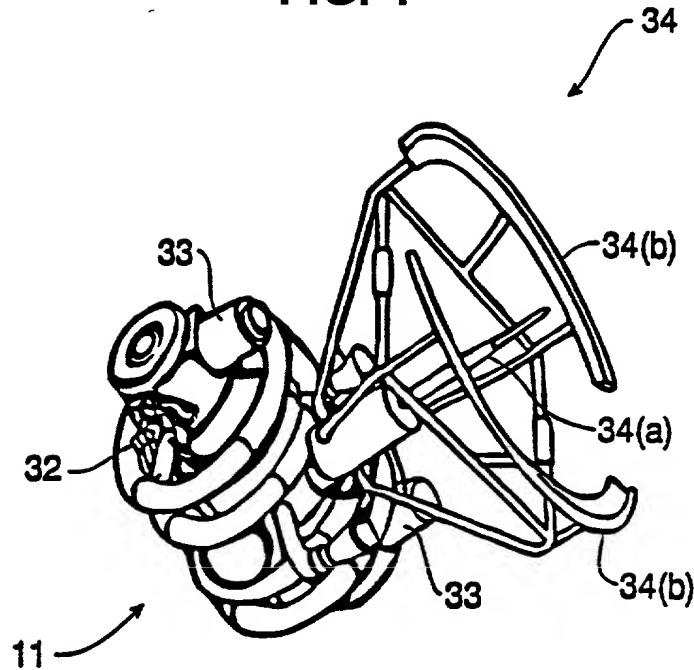


FIG. 5

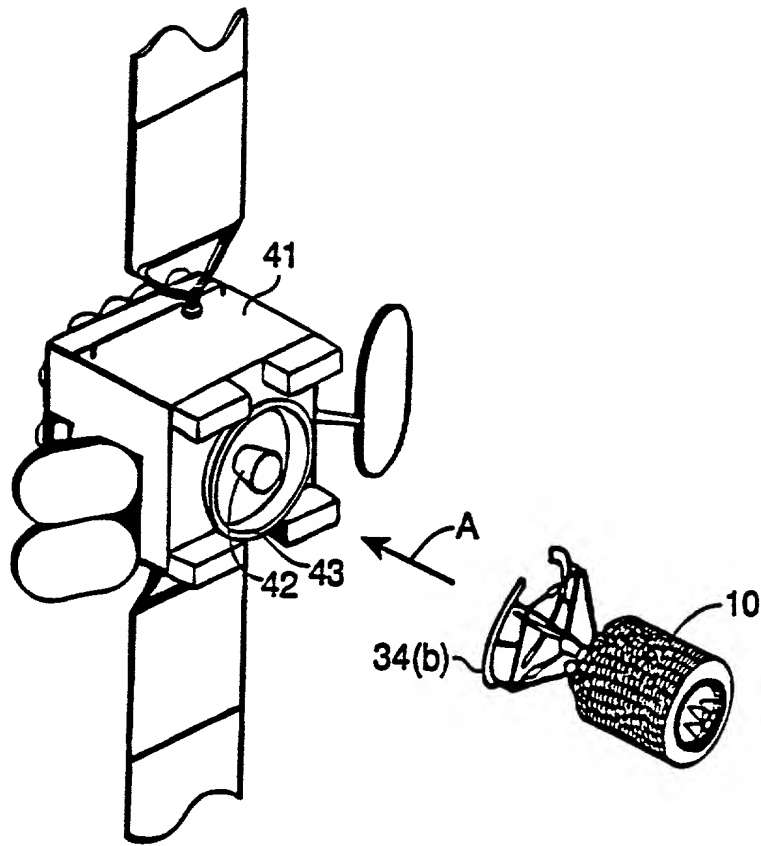


FIG. 6(a)

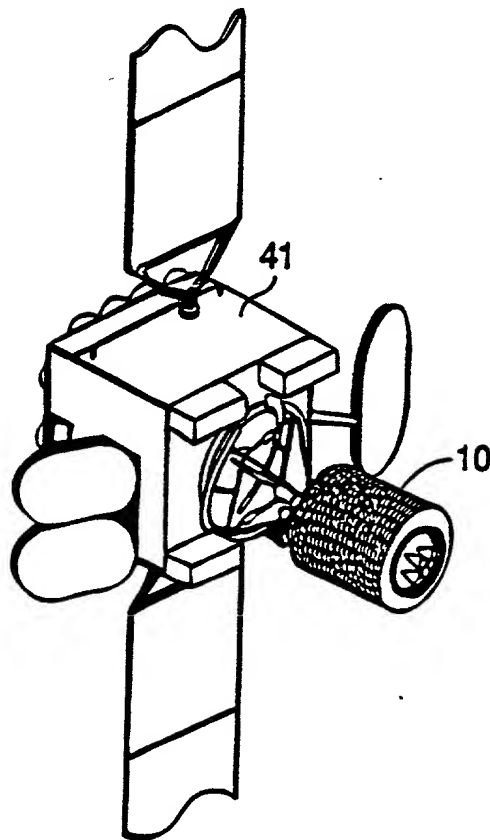


FIG. 6(h)

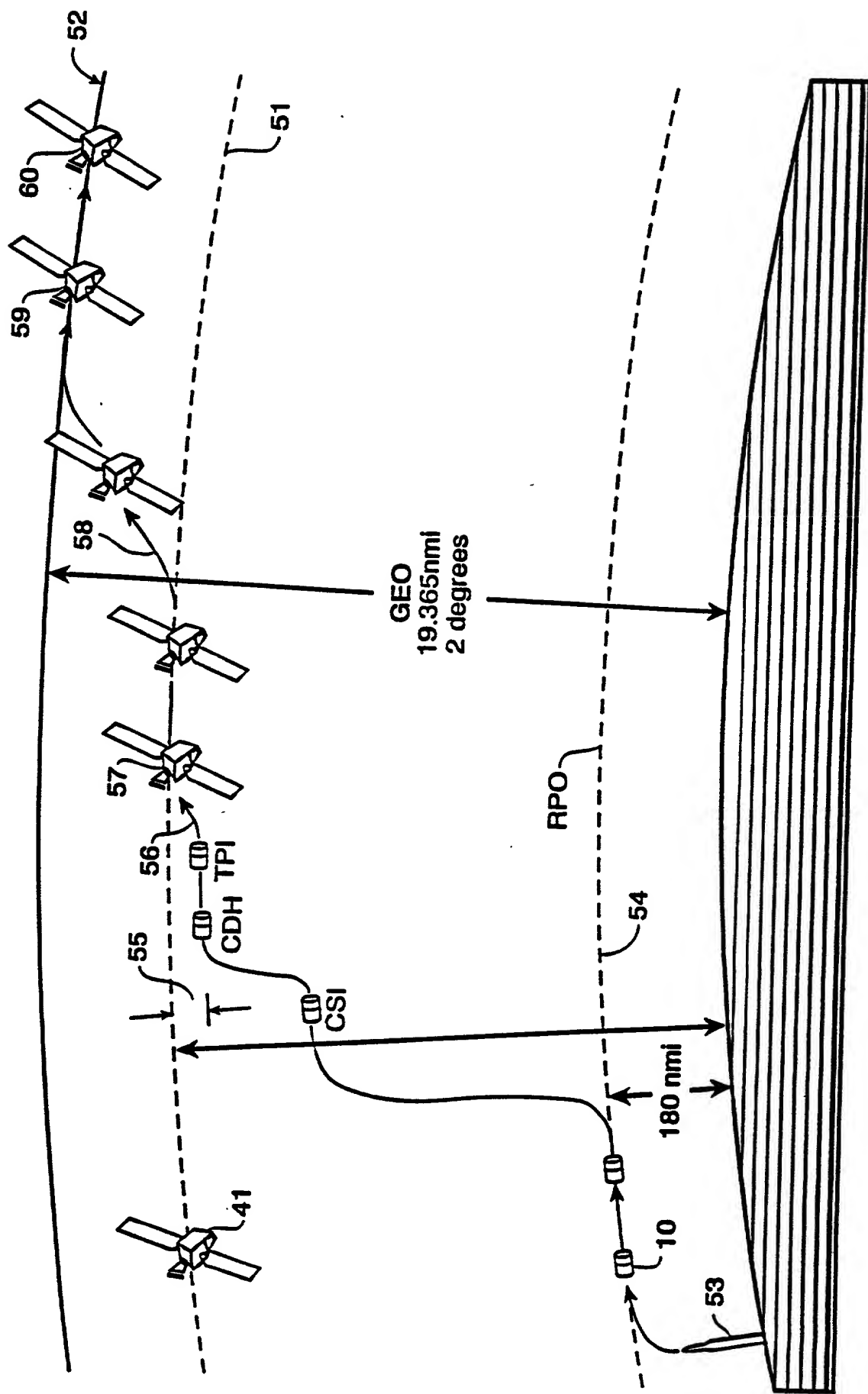


FIG. 8

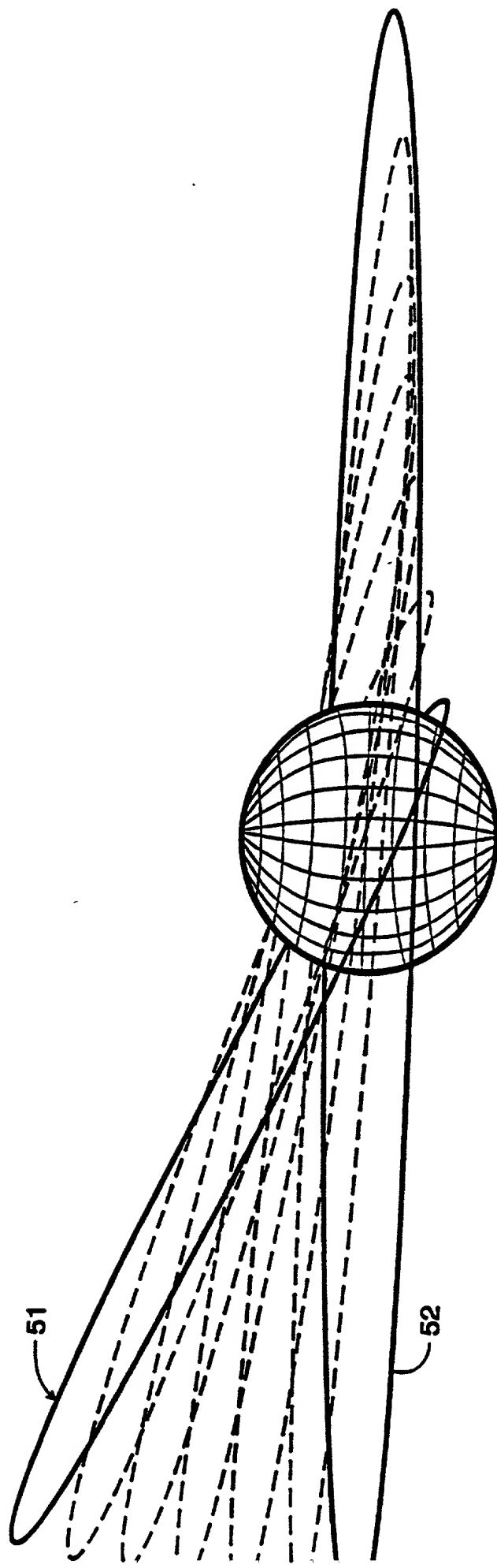


FIG. 9

Docket No.
277-P-32-USA

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

METHOD OF INSURING AGAINST SATELLITE LAUNCH FAILURE

the specification of which

(check one)

☒ is attached hereto.

☐ was filed on _____ as United States Application No. or PCT International Application Number _____ and was amended on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Priority Not Claimed

_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	<input type="checkbox"/>
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	<input type="checkbox"/>
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	<input type="checkbox"/>

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.)

(Filing Date)

(Application Serial No.)

(Filing Date)

(Application Serial No.)

(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)

(Filing Date)

(Status)
(patented, pending, abandoned)

(Application Serial No.)

(Filing Date)

(Status)
(patented, pending, abandoned)

(Application Serial No.)

(Filing Date)

(Status)
(patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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Residence	
Citizenship	
Post Office Address	